A table given by Sir Philip Watts comparing the weights apportioned to the different elements of design in a battleship of 1805 and of a modern battleship respectively is interesting. The old ship is one of 74 guns, and 20 per cent. of the total displacement was awarded to general equipment as against 4 per cent. for the 1905 battleship. Armament in 1805 was 10 per cent. of the displacement; in the present day it is 19 per cent. The propelling arrangements are somewhat in the nature of a surprise, masts, sails, and rigging absorbing 8·5 per cent., and steam machinery only 10·5 per cent. of the displacement. There is, however, to be added to the latter figure 5·5 per cent. for coal, but this is more than balanced by the 6·5 per cent. of the weight apportioned to ballast for giving the stability needed under sail. Armour is naturally the great point of difference, for it takes up 26 per cent. of the displacement of a modern battleship. As against this but 35 per cent. of the total displacement is needed for the construction of steel hulls, whilst the wooden hull absorbed 55 per cent. of the total tonnage. It must be remembered, however, that the construction of the "wooden walls" was far more massive than was needed for ordinary purposes, and a good part of the 55 per cent. might be set down as wooden armour. The remarkable thing is that iron plates were not applied earlier, before the French constructors set us the example; or, rather, it would be remarkable were the very conservative nature of the old admirals not remembered.

THE LIGHT-PERCEIVING ORGANS OF PLANTS.[1]

THE subject of this most suggestive book has already been dealt with by the author in a preliminary way.[2] In its present form it has gained greatly in force and interest, and whether or no we are finally converted to Prof. Haberlandt's views there can be no doubt that they are worthy of serious attention.

It is well known that the majority of leaves have the power of placing themselves at right angles to the direction of incident light, but the question of how the light stimulates the leaf to perform the curvatures and torsions which bring it into the "light position" is a problem which hitherto has hardly been attacked.

The first question to be solved is what part of the leaf is sensitive to light. By covering the blade of the leaf with black paper, &c., Haberlandt shows that the principal and most delicate sensitiveness resides in the blade, although a coarser and secondary sensitiveness to the incident light is found in the stalk. It results from this part of the inquiry that the lamina of the leaf must contain the organs for light-perception, if such organs exist. Anything corresponding to a visual organ may be expected to be on the surface, although in such a translucent organ as a leaf this does not necessarily follow. It may, however, be said that Haberlandt is amply justified in looking for what he calls the ocelli of plants in the epidermis covering the upper surface of the leaf. We may therefore narrow the problem thus. Imagine a horizontal leaf illuminated by light striking it obliquely from above at 45°; such a leaf is not in the "light position," and will execute a curvature through 45°, in fact until it receives light at right angles to its surface. Then curvature ceases and the leaf remains in a state of equilibrium—satisfied, as it were, with the "light position." The question is how the leaf differentiates between oblique and perpendicular illumination. Direct observation suggests an answer. If the epidermis of such a leaf as that of *Begonia discolor* be removed by a surface section, and mounted upside down and illuminated from below, then with a low power of the microscope it can plainly be seen that there is a bright spot of light on the basal (inner) walls of the epidermic cells. It can further be seen that the relation of the spot of light to the surrounding zone (which is more or less dark) changes when the specimen is obliquely illuminated. Thus in the case of the obliquely illuminated leaf we should have to imagine that the leaf is stimulated to curvature by the fact that the spots of light are not central in the cells, and that curvature ceases when the brightest illumination is once more central. Thus the plasmic membrane of the basal wall of each epidermic cell is supposed to have a quasi-retinal function by which the leaf is believed to orientate itself in regard to light. There is here, as Haberlandt points out, a certain resemblance to the mechanism by which plants are by many botanists believed to react to gravitation, namely, by the pressure of solid bodies on different parts of the cell walls, just as the statoliths (otoliths) of certain animals, by pressure on different parts of the membrane of the statocyst, enable them to orientate themselves in space.

Haberlandt shows that the epidermic cell is well fitted to concentrate light. It is very commonly lens-like in form, its outer wall being convex, its inner wall either plane or curved. Haberlandt shows by geometrical construction that, taking the refractive index of the cell sap as equal to that of water, the focus is usually at a point either within the cell or below it in the other tissues. In either case a central illuminated region and a surrounding dark zone is produced on the basal cell wall. A further development of this type is the papillose epidermic cells which give the velvety appearance to certain tropical leaves. This does not differ essentially from the first described type, but it has, according to the author, certain advantages which will be referred to later on. It must not be supposed that all leaves have lens-shaped epidermic cells; some leaves, known as aphotometric, are indifferent to the direction of incident light, and even in photometric leaves Haberlandt shows that discrimination is possible without the epidermis playing the part of a lens. Where the outer wall of the epidermis is flat, it often occurs that the inner wall bulges into the subjacent tissues or projects into them in the form of a truncated pyramid. In this case, when the light strikes the leaf at right angles, the central part of the basal wall, being more or less parallel to the surface, is more strongly illuminated than its peripheral parts, which are oblique. Thus without any lens-effect we get stronger illumination in the central region of the basal walls of the epidermis; and this may conceivably serve as a means of orientation.

The most conclusive proof of the author's theory is given by the results of placing the experimental plants under water. If he is right in claiming a lens-function for the epidermic cells, it is clear that immersion in a fluid which has approximately the same refractive index as the cell sap must interfere with the plant's power of light-perception; and this is, in fact, the outcome of his experiments.

His first experiments (p. 89) were made with the hop (Humulus). Here, as in other cases, the stimulus of light is perceived by the leaf, and less perfectly by

[1] "Die Lichtsinnesorgane der Laubblätter." By Dr. G. Haberlandt o. ö. Professor der Botanik a. d. Universität Graz. Pp. viii+143 (Leipzig: Engelmann, 1905.) Price 6s. net.

[2] *Berichte d. deutsch bot. Gesellschaft*, Bd. xxii., 1904 (February), and in an address given in 1904 before the Gesellschaft deutscher Naturforscher und Aezte, and published by Barth, of Leipzig.

the leaf-stalk. Four leaves were immersed, two (D) having their leaf-stalks darkened with tin-foil, while the stalks of the other two (L) were exposed to oblique light. After three or four days the D leaves showed no signs of taking up the light-position, while the two L leaves showed well marked curvature towards that position. The experiment is of importance, since it shows that immersion in water does not prevent heliotropic curvature by interfering with respiration or by depressing the energy of the plant in any other way. The only explanation seems to be that of the author, viz. that in the leaves (D) with darkened stalks the lens-like epidermic cells of the leaf-blade are the only organs of light-perception, and they being thrown out of action by the presence of water, perception (and therefore curvature) is absent.

Experiments of the same type were made with a like result on *Ostrya vulgaris* and *Begonia discolor*. It is to be regretted that the light-perceiving organs of such leaf stalks as were sensitive to light under water were not investigated.

A striking result was obtained with Tropæolum (p. 92). The leaves of this plant are unwettable, and when immersed remain coated with a silvery mantle of air. The waxy layer, which gives this quality, may be removed by painting the surface with dilute alcohol without injury to the leaves. The result of immersion is that the normal leaves protected by a layer of air react normally to oblique illumination, whereas the wettable leaves have lost the power of so reacting. This interesting result suggests to the author a new function for the waxy "bloom" of leaves, *i.e.* that it saves them from being blinded by a shower of rain. This theory he extends to velvety leaves, the strongly papillated epidermic cells of which stand up like islands when the surface of the leaf is wetted (p. 65). This is a striking fact in relation to the distribution of velvet-leaved plants, which are especially common in damp tropical regions.

Another section of Haberlandt's evidence depends on the existence of highly specialised lenses. One of the most curious is that of *Fittonia Verschaffeltii* (Acanthaceæ), shown in Fig. 1. Here we have a

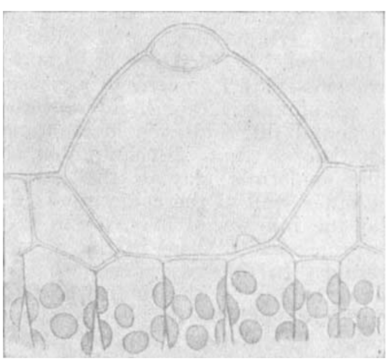

FIG. 1.—Ocellus of *Fittonia Verschaffeltii*.

dwarfed, two-celled trichome, of which the apical cell has the form of a biconvex lens. In this case there is a division of labour, the light focused by the lens-cell being perceived by the large basal cell. Direct experiment shows that, as might be expected, painting the leaf with water in no way interferes with the effect, since the lens is raised above the layer of wet. Similar ocelli occur in *Impatiens mariannae*, and here, as in Fittonia, it is interesting to note that the ordinary epidermic cells, among which the ocelli occur, are markedly bad lenses.

Quite a different type of lens occurs in *Campanula persicifolia*; here (Fig. 2) the formation of a spot of light does not depend on the form of the epidermic cell as a whole, but on the existence of a lens-shaped silicified region in the outer wall of the cell. These structures only occur in perfection in a shade-loving form of the species, where they were noted by Heinricher, who was unable to suggest a function for them. Direct observation proves that they are highly effective lenses. Similar organs are found in *Petraea volubilis*. We must pass over a number of other interesting specialised organs, but it is of importance to note that whenever ocelli occur they

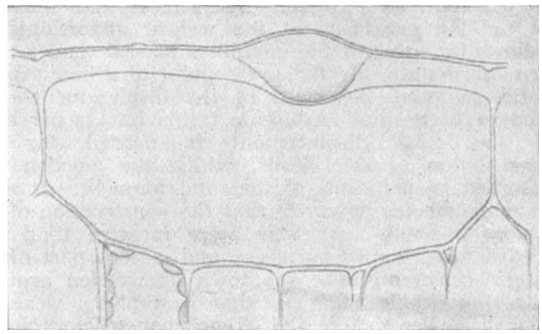

FIG. 2.—Ocellus of *Campanula persicifolia*.

are to be found on the upper, and not on the lower, surfaces of leaves. It is also particularly interesting to find that ocelli tend to occur especially near the edges of leaves, *i.e.* just in those regions where the amount of movement, corresponding to curvature through a given angle, is greatest.

The author has once more earned the gratitude of his fellows by his suggestive discoveries and speculations He must be allowed to have made out a strong case for his theory, but he would be among the first to grant that more work is needed before it can be considered as completely established.

F. D.

RECENT PUBLICATIONS IN AGRICULTURAL SCIENCE.

EVERY civilised State has recognised a special duty towards its farmers in the way of endeavouring to secure them against the purchase of adulterated manures, fraudulent feeding stuffs, and dead or impure seed, but different countries have taken very various means towards securing the desired end. The United Kingdom, probably because its representative farmers are men of substance, rather holds by the old *caveat emptor* maxim, and is content with providing the farmer with a machinery for getting an analysis below cost price, but a machinery sufficiently cumbrous to ensure that no one sets it in motion. Other nations, less intent, perhaps, upon a plausible case in Parliament, and more concerned in getting the thing itself done, have devised various systems of controlling the trade in such materials, so as to ensure that the smallest farmers shall be supplied with seed or manures reaching a certain standard of purity. The laws and methods adopted for securing such a control in the various States Prof. Giglioli passes in review,[1] giving an account of the testing stations, the regulations, the fees, and even notes on the working details employed in the labor-

[1] "Concimi, Mangimi, Sementi, &c., Commercie, frodi, e repressione delle frodi, Specialmente in Italia." By Italo Giglioli. Pp. xvi+759 (Rome: Annali d'Agricoltura, 1905.)